RESEARCH STUDY ON INTER-VEHICLE COMMUNICATION IMPLEMENTATION IN MALAYSIA

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for the award of the degree of
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT’S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurently submitted for award of other degree.

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ABSTRACT

Vehicle-to-Vehicle (V2V) communications systems have recently drawn great attention, because they have the potential to improve convenience and safety of car traffic. Road accidents take the life of many people in the world each year, and much more people have been injuring and maiming. Statistical studies show that accidents could be avoid by 60% if drivers were informed only half a second before the accident. The objective of this report is to make an analysis of the possibility of implementing this technology in Malaysia. This research study is as guidance to develop a concept of V2V system. Applications with early deadlines are expected to require direct V2V communications, and the only standard currently supporting this is the IEEE 802.11p, included in the wireless access in vehicular environment (WAVE). The combination of WAVE and GPS is a good idea to forming collision avoidance system. The GPS system determines the location of vehicles and the WAVE system forming an ad- hoc peer-to-peer networking among the vehicles.V2V communication enable vehicle to communicate with their neighbouring vehicles even in the absence of a central base station to provide a safer and more efficient roads and to increase passenger safety. This technology can be implements in Malaysia but in order to do it some changing had to be made first to ensure the effectiveness of the technology. V2V communication should have a Doppler sensor as a device sensor that can integrates with cruise control to form adaptive cruise control. Other than that, it also need WAVE to assure a reliable communication system between vehicles. The GPS system is needs to determine exact location of car that can be use in roadways environment such as overtaking situation.

ABSTRAK

Sistem komunikasi antara kenderaan (V2V) baru-baru ini telah menarik perhatian besar, kerana sistem ini mempunyai potensi untuk meningkatkan keselesaan dan keselamatan lalu lintas. Kemalangan jalan raya meragut banyak nyawa di seluruh dunia setiap tahun, dan ramai lagi yang telah cedera akibat kemalangan jalan raya. Statistik kajian menunjukkan bahawa sebanyak 60% kemalangan boleh dielakkan jika pemandu di beri amaran hanya setengah saat sebelum kemalangan berlaku. Tujuan laporan ini dibuat adalah untuk melakukan analisis tehadap kemungkinan mengimplimantasikan teknologi ini di Malaysia. Penelitian ini adalah sebagai bimbingan untuk membangunkan sistem V2V di malaysia. Aplikasi dengan waktu tamat awal memerlukan komunikasi langsung V2V, dan satu-satunya komunikasi pada saat ini menyokongnya adalah IEEE 802.11p,yang termasuk dalam akses tanpa wayar dalam persekitaran kenderaan (WAVE). Kombinasi WAVE dan GPS adalah idea yang baik untuk membentuk sistem mengelakkan pelanggaran. Sistem GPS menentukan lokasi kenderaan dan sistem WAVE membentuk sebuah rangkaian peer-to-peer ad-hoc antara kenderaan. Komunikasi V2V membolehkan kenderaan berkomunikasi dengan kenderaan jiran mereka tanpa perlu adanya stesen pangkalan pusat untuk memberikan kondisi jalan yang lebih selamat dan lebih efektif untuk meningkatkan keselamatan pemandu.Teknologi ini dapat aplikasikan di Malaysia tetapi untuk melakukannya beberapa pengubahan harus dibuat untuk memastikan keberkesanan teknologi. Komunikasi V2V mesti mempunyai sensor *Doppler* sebagai sensor peranti yang boleh berintegrasi dengan cruise control untuk membentuk *adaptive cruise control*. Selain itu WAVE juga diperlukan untuk memastikan sistem komunikasi yang selamat antara kenderaan. Sistem GPS adalah diperlukan untuk menentukan lokasi yang tepat daripada kereta

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LIST OF ABBREVIATIONS

ABS	Antilock Braking System
ACK	Acknowledgment
AIFS	Arbitration Interframe Space
BSS	Basic Service Set
BSSID	Basic Service Set Identification
CSMA/CA	Carrier Sense Multiple Access With Collision Avoidance
DCF	Distributed Coordination Function
DSP	Digital Signal Processing
DSRC	Dedicated Short Range Communication
EDCA	Enhanced Distributed Channel Access
FCC	Federal Communication Commission
FFT	Fast Fourier Transforms
FOKUS	Fraunhofer Institut für offene Kommunikationssysteme
GPS	Global Positioning System
In-V	Intra-Vehicle
IVC	Inter-Vehicle Communications
JARI	Japan Automobile Research Institute
MAC	Media Access Control
OBE	On-Board Equipment
OBU	On-Board Unit
OFDM	Orthogonal Frequency-Division Multiplexing
PHY	Physical Layer
STDMA	Self-Organizing Tdma
TELCO	Telecommunication Network for Cooperative Driving
UWB	Ultra-Wideband
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VII	Vehicle Infrastructure Integration
WAVE	Wireless Access for Vehicular Environments
WLAN	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Inter-Vehicle Communications (IVC) systems have recently drawn great attention, because they have the potential to improve convenience and safety of car traffic. IVC represents communication between vehicle or vehicle and sensors placed in or on various locations, such as roadways, signs parking areas, and even the home garage. For example, sensor-equipped cars that communicate via wireless links and thus build up ad-hoc networks can be used to reduce traffic accidents and facilitate traffic flow. Emerging vehicular in the terms of Intra-Vehicle (In-V), Vehicle-to-Vehicle (V2V), and, Vehicle-to-Infrastructure (V2I) communications are fast becoming a reality and will enable a variety of services for safety, traffic efficiency, driver assistance, as well as infotainment to incorporate into modern automobile designs. IVC can be considered to be more technically challenging because vehicle communications need to be supported both when vehicle are stationary and when they are moving. This research will be focus on V2V communication.

Vehicle-to-Vehicle (V2V) communication can promote more safety. Exchange of information regarding vehicle dynamics and road condition among vehicles could play a crucial role in driver and passenger safety. A driver, provided with information about road conditions and velocities of the vehicles around it, is able to make better decisions concerning vehicle control and travel path. When vehicles communicate their real-time velocity values, a driver can avoid accidents by adjusting her velocity according to neighbouring vehicle velocities

1.2 PROBLEM STATEMENT

Road accidents take the life of many people in the world each year, and much more people have been injuring and maiming. Statistical studies show that accidents could be avoid by 60% if drivers were informed only half a second before the accident (C. D. Wang and J. P. Thompson, 1997). The main reason of these accidents is a limitation in view of roadway emergency events that can be due to the distances, darkness, and existence of an inhibiter in the road. In addition, a delay of the vehicle's driver to react against the events on the roadway could make irreparable results. Road and traffic safety can be improved is drivers have the ability to see further down the road and know if a collision has occurred. This can become possible if the drivers and vehicles communicate with each other. If traffic information was provided to drivers, police and other authorities, the road would be safer and travelling on them would become more efficient. It is possible to build a multi-hop network among several vehicles that have communication devices. These vehicles would form a mobile ad-hoc network and could pass along information about road conditions, accidents and congestion.

The graph below shows the number of crashes and number of fatal crashes than happen from 1979-2009.

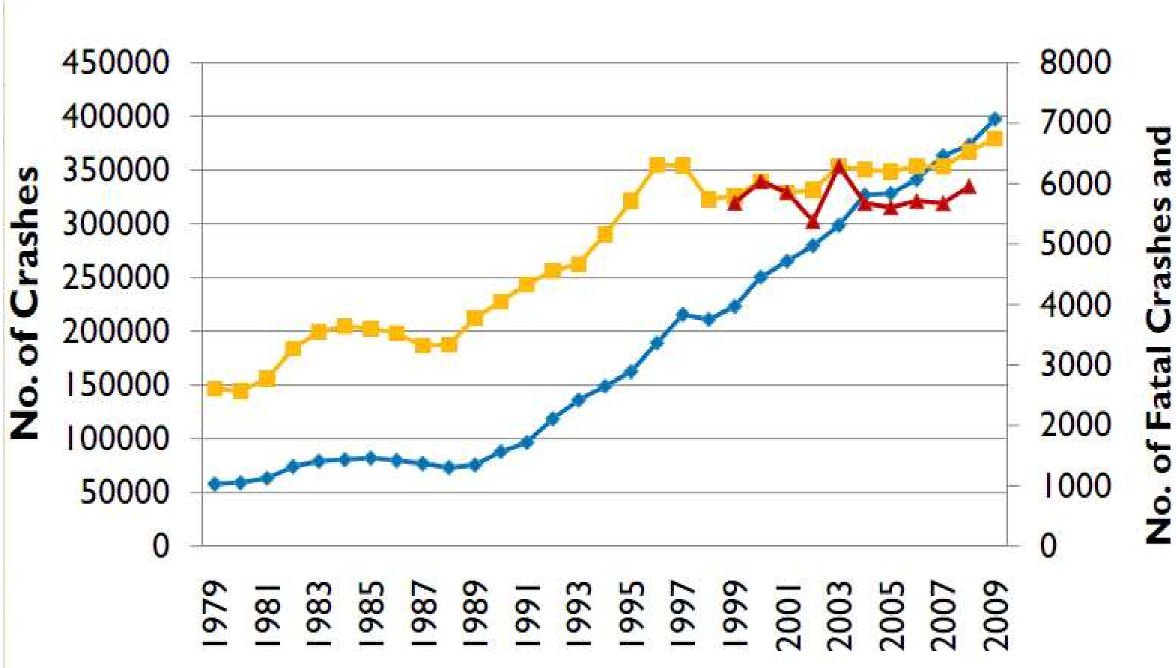

Figure 1.1: Graph for number of crashes and number of fatal crashes over the year.

Sources: (MOHAMED, 26 MARCH 2010)

The graph clearly shows that the no of crashes is increasing by a year. The numbers of fatal crashes also increase with the increasing number of crash. When the number of crashes is higher, the possibility for fatal crashes to occur will be higher. This problem will be continue to increase because the increasing the number of vehicle on the road.

The bar chart below show that the collision type that occur and the numbers of non-fatal and fatal crash resulting from the collision.

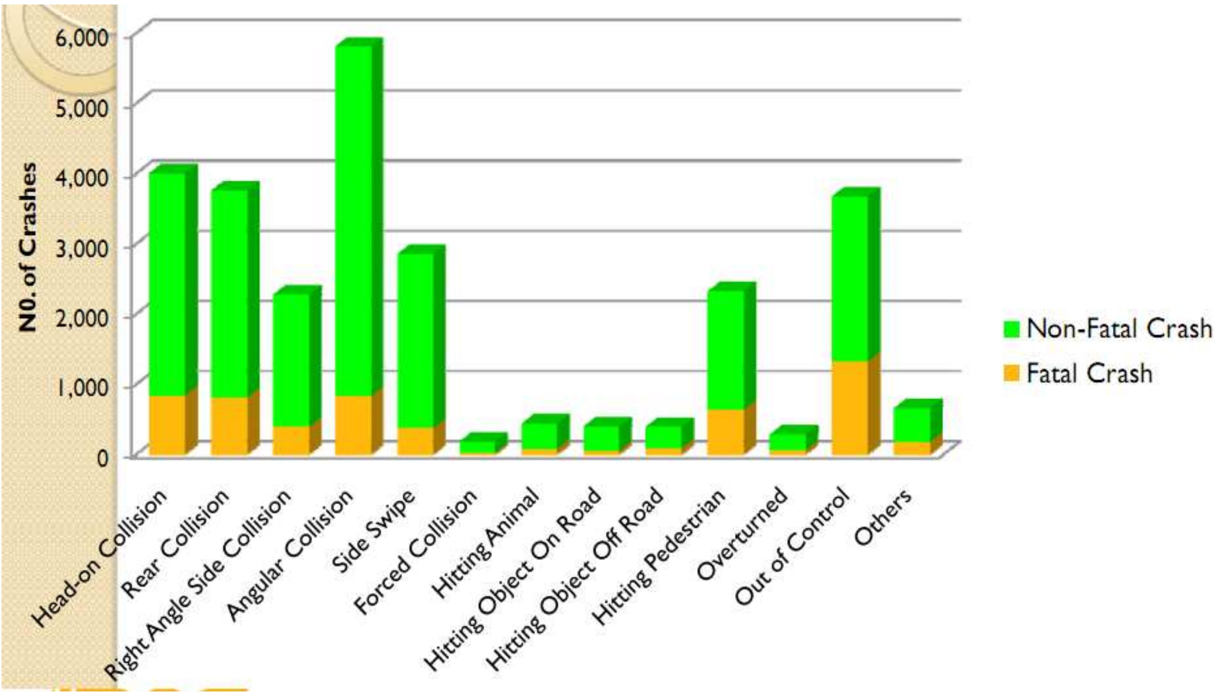

Figure 1.2: Bar chart for the number of crashes versus type of collision.

Sources: (MOHAMED, 26 MARCH 2010)

Refers to the bar chart, some of the crashes can be avoid or prevent by using IVC communications. With this technology, vehicle can communicate with each other and could send along information regarding vehicle velocity and road condition among vehicles. When vehicles communicate their real-time velocity values, a driver can avoid accidents by adjusting his velocity according to neighbouring vehicle velocities. These all problem regarding the accidents can be solved by using IVC.

1.3 PROJECT OBJECTIVES

The objective of this project is to research and propose a concept of inter vehicle communication (IVC) that suitable to be implemented in Malaysia.

1.4 PROJECT SCOPES

The scopes of this project are to investigate and propose recommendations on possibility IVC concepts in Malaysia. The research will focused on the possible communications system and protocol that can used between vehicles.

CHAPTER 2

VEHICLE-TO-VEHICLE COMMUNICATION SYSTEM

2.1 INTRODUCTION

This chapter explains in detail Vehicle-To-Vehicle (V2V**)** found in literature. The main purpose of this research study is as guidance to develop a concept system and to evolve current system. V2Vcommunications are going to create new services by transmitting packets from vehicle to vehicle without the use of any deployed infrastructures. These services will enable the vehicle to transmit necessary data such as the current location, the motion's direction, and the speed directly to other vehicle. It is possible to build a multihop network among several vehicles that have communication devices. These vehicles would form a mobile ad hoc network, and could pass along information about road conditions, accidents, and congestion. A driver could be made aware of the emergency braking of a preceding vehicle or the presence of an obstacle in the roadway. It can also help vehicles negotiate critical points like blind crossings at the intersections without traffic lights or entries to highways.

2.2 HISTORY OF V2V

Nowadays we are on the verge of witnessing a revolution in automotive technology. V2V has attracted research attention from both academia and industry in the US, EU, and Japan. V2V communications systems have the potential to improve convenience and safety of car traffic. For example, sensor equipped cars that communicate via wireless links and build up ad-hoc networks can be used to reduce traffic accidents. One of the earliest studies on V2V communication started by JSK (Association of Electronic Technology for Automobile Traffic and Driving) of Japan in early 1980s. In 1999, the U.S Federal Communication Commission (FCC) allocated 75 MHz of spectrum at 5.9GHz used exclusively for vehicle-to-vehicle and infrastructure-to-vehicle communication in the U.S called Dedicated Short Range Communication (DSRC). Later, California PATH and Chauffeur of EU have demonstrated research results. The newly initiated European Project CarTALK 2000 covers problems related to safe and comfortable driving based on IVC. CarTALK 2000 also co-operates with other projects like German FleetNet for the development of IVC. The Vehicle Infrastructure Integration (VII), a major initiative at the United States Department of Transportation envisions that a future vehicle will be equipped with an On-Board Equipment (OBE), which consists of an On-Board Unit (OBU), which is essentially a transceiver, a GPS receiver, and a computer. On December 17, 2003, the FCC adopted licensing and service rules for DSRC and lower layer standards developed by the ASTM 5.9 GHz standards working group. An international standard, IEEE 802.11p, also known as Wireless Access for Vehicular Environments (WAVE), was recently publishs. Shown below table 2.1 are some of the consortiums that associated with V2V communications development. (Issam Khalil, January 2006)

Table2.1: Consortiums associated with V2V communications development.

Consortium	Participants	Mission
Vehicle Safety Communication Consortium (VSC) (Founded 05/2002)	DAIMLERCHRYSLER Ford GM NISSAN TOYOTA DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA	• Facilitate the advancement of vehicle safety through communication technologies. • Identify and evaluate the safety benefits of vehicle safety applications enabled or enhanced by communications. • Assess associated communication requirements including vehicle-vehicle and vehicle-infrastructure communications. • Contribute to 5.9GHz DSRC standards and ensure they effectively support safety.
EUCAR SGA (Founded in 05/2002)	Ford OPEL DAIMLERCHRYSLER PEUGEOT RENAULT	• Coordination of European pre-competitve activities in the field of telematics • Develop Inter-vehicle hazard warning based on 900Mhz Funkwarner technology in Europe • Define basic message set for safety messages
Car2Car Communication Consortium (C2CC) (pending)	Audi DAIMLERCHRYSLER	• Specification of an industrial standard for an open inter-vehicle communication platform and for basic safety applications. • To achieve allocation of an European frequency band dedicated for active safety applications. • To include other OEMs and suppliers into the consortium.

Source: (Holfelder, 2004)

A number of research projects around the world have been focusing on inter-vehicle communication systems. This section will present some of the larger projects.

In Europe, projects such as DRIVE investigated IVC systems for a safer and environmentally friendly transportation. The European Automotive Industry launched the Program for European Traffic with Highest Efficiency and Unprecedented Safety (PROMETHEUS) in 1986; its main objective was to make driving in Europe safer, more economical, more environmentally acceptable, more comfortable, and more efficient. (Issam Khalil, January 2006)

The PATH project is collaboration between the California Department of Transportation (Caltrans), the University of California, other public and private academic institutions, and industry. Its main mission is to apply advanced technology to increase highway capacity and safety, and reduce traffic congestion, air pollution, and energy consumption. PATH has generated a number of publications and prototypes in the area of IVC systems primarily focused on cooperative driving and vehicle platooning. As part of the project, they developed SHIFT, a realistic traffic simulator that also integrates communication components, thus being especially suitable for the evaluation of IVC systems. As part of the PATH project, a successful experiment with eight vehicles in a platoon formation was demonstrated (Benouar, 2002).

Fleetnet was a project that set up by a German consortium of six companies and three universities that is Daimler-Chrysler AG, Fraunhofer Institut für offene Kommunikationssysteme [FOKUS], NEC Europe Ltd., Robert Bosch GmbH, Siemens AG, TEMIC Speech Dialog Systems GmbH, Universities of Hannover and Mannheim, and Technische Universität Hamburg-Harburg and Braunschweig. The project was funded between 2000 and 2003. The main objective of the Fleetnet project was to develop a platform for IVC systems. The project focused on three classes of applications: cooperative driving, traffic information, and comfort applications. Since 2004 until 2008, most of the members of the Fleetnet consortium are working on a new project named Network on Wheels. The main objectives of this project are to solve questions on the communication protocols and data security for targeted vehicular communications.

CarTalk 2000 (2001–2004) was funded by the European Union within the 5th Framework program. The partners in the project were Daimler-Chrysler AG, Centro Recherché Fiat, Robert Bosch GmbH, and Siemens, Netherlands Organization for Applied Scientific Research, the University of Cologne, and the University of Stuttgart. The main objectives of the project were the development of cooperative driver assistance systems and a self-organizing ad-hoc radio network as the basis for communication with the aim of preparing a future standard (Issam Khalil, January 2006).

The Japan Automobile Research Institute (JARI), formerly the Association of Electronic Technology for Automobile Traffic and Driving (JSK), has a number of projects studied V2V systems since the early 1980s. In the 1990s, the project focused on cooperative driving; now it has shifted toward the standardization of IVC systems. One of the projects demonstrated a prototype for traffic coordination (DEMO 2000). In Italy, the Telecommunication Network for Cooperative Driving (TELCO) project has investigated the feasibility of an IVC system working at millimetre waves between 60 and 64 GHz. They have also investigated IVC systems based on GPRS and 3G networks (Issam Khalil, January 2006).

2.3 EXISTING COMMUNICATION TECHNOLOGY FOR V2V SYSTEM

2.3.1 Bluetooth

Bluetooth is a wireless technology optimized for short-range communication with low power. A Bluetooth ad-hoc network, called a piconet, accommodates up to seven users. Piconets that have common users can form a scatter net. However, the common user can be active in one piconet at a time. In a piconet, an arbitrary user plays the role of the “master" and the other users act as “slaves". Initially, different users have different clock times but in a piconet the slave clocks are synchronized with the master clock. A slave can be in the active communication or standby mode. The master controls the medium access. It polls the slaves for communication and schedules the transmission of the active users based on traffic demands to and from the different slaves. In addition, it supports regular transmissions to keep slaves synchronized to the channel. It is reliable up to a speed of 80 km/h and range of 80 m. However, it can take up to 3 seconds to establish the communication. In addition, since Bluetooth requires a master and slave setup, the master could potentially refuse a communication request. In addition, the master may already be communicating with another slave, which would lower the possible communication rate (Bicke, 2006).

2.3.2 Ultra-Wideband (UWB)

An alternative to Bluetooth is a new radio frequency technique called UWB. UWB technology loosely defined as any wireless transmission scheme that occupies a bandwidth of more than 25% of a centre frequency, or more than 1.5GHz. UWB uses very short pulses, so that the spectrum of the emitted signals spread over several GHz, because of the wideband nature of the signal, UWB has been used in radar applications. The Federal Communication Commission (FCC) refers to UWB technology as having high values of fractional bandwidth .The main advantages of UWB technology are its high data rate, low cost, and immunity to interference. On the other hand, it could possibly interfere with other existing radio services, for instance, the Global Positioning System (GPS). Because of a lower bit error rate, the coded Gaussian pulses waveform is thought to be superior to monocycle pulses. The system is not believed to be too sensitive to multipath or jitter effects. The fact that UWB could potentially interfere with communication sources is a technical problem that must be solved before it could be used in V2V systems. Also, there is a concern that UWB's radio coverage could extend to uninvolved vehicles, which could generate false or irrelevant information (Bicke, 2006).

2.3.3 Dedicated Short Range Wireless Communications (DSRC)

DSRC is a multi-channel wireless standard that based on the IEEE 802.11a PHY and the IEEE 802.11 MAC. It is targeted to operate over a 75 MHz licensed spectrum in the 5.9 GHz band allocated by the FCC in 1999 for the support of low-latency V2V communications. Clearly, communications-based V2V safety systems should not operate in an unlicensed band either at 2.4 GHz or 5 GHz. The creation of hand-held and hands-free devices that occupy these bands, along with the projected increase in

Wi-Fi hot spots and wireless mesh extensions, could cause intolerable and uncontrollable levels of interference that could disable the reliability and effectiveness of low-latency vehicular safety applications. This, in turn, makes a strong case for investigating DSRC as a potential candidate for supporting low latency vehicular safety applications to reduce collisions and save lives on the road. Even with a licensed band, cooperative spectrum management must ensure reliable and fair access to all applications, including priority scheduling of traffic between different application classes as well as within a given class. Unlike 802.11, multi-channel coordination is a fundamental capability of DSRC. Although IEEE 802.11 PHY supports multiple channels, MAC operation over the multiple channels is left optional to individual vendors and is not supported by the standard. As pointed out earlier, DSRC is similar to IEEE 802.11a, except for the major differences operating frequency band, application environment, MAC layer and physical layer. Operating Frequency Band for DSRC is targeted to operate in a 75 MHz licensed spectrum around 5.9 GHz, as opposed to IEEE 802.11a which is allowed to utilize only the unlicensed portions in the 5 GHz band. Application Environment, DSRC is meant for outdoor high-speed vehicle up to 200 km/h applications, as opposed to IEEE 802.11a originally designed for indoor WLAN applications. Thus, all PHY parameters are optimized for the indoor low-mobility propagation environment. This brings new challenges for wireless channel propagation with respect to multi-path delay spread and Doppler effects caused by high mobility. DSRC MAC Layer, the DSRC band plan consists of seven channels which include one control channel to support high priority safety messages and six service channels to support non-safety applications. Prioritizing safety over non-safety applications is an open problem that started to receive attention in the literature and is closely related to the problem of multi-channel coordination. Aside from these differences, the DSRC MAC follows the original IEEE 802.11 MAC and its extensions, for example IEEE 802.11e QoS. The bandwidth of each DSRC channel is 10 MHz, as opposed to the 20 MHz IEEE 802.11a channel bandwidth. Clearly, this has direct impact on the maximum data rate DSRC can support (27 Mbps), as well as timing parameters and frequency parameters. A side from these and some differences in the transmit power limit, the DSRC PHY follows exactly the same frame structure, 64 sub-carrier OFDM-based modulation scheme, and training sequences specified by IEEE 802.11a PHY. Thus, the impact of the drastically different vehicular environment on the DSRC PHY performance needs thorough investigation (Soheila V. Bana, 2001).

2.3.4 Wireless Access for Vehicular Environments (WAVE)

The IEEE 802.11p workgroup is currently working on standardizing the wireless access for vehicular environment (WAVE). WAVE is the next generation dedicated short-range communications (DSRC) technology, which provides high-speed V2V data transmission and has major applications in intelligent transportation systems (ITS), vehicle safety services and Internet access. Operating at 5.850-5.925GHz, WAVE systems adopt orthogonal frequency-division multiplexing (OFDM) and achieve data rates of 6-27Mbs/s. WAVE technology is a revolution solution for vehicle safety enhancement by providing drivers with early warning, perceive and assistance. It is an extension of humans natural sensing and realizes telesensing of vehicles. WAVE systems will build upon the IEEE 802.11p standard. The IEEE802.11p standard is meant to describe the functions and services required by WAVE-conformant stations to operate in a rapidly varying environment and exchange messages without having to join a Basic Service Set (BSS), as in the traditional IEEE 802.11 use case. The BSS is a term used to describe the collection of stations which may communicate together within an 802.11 WLAN (Wireless Local Area Network).Vehicular safety communications use cases demand instantaneous data exchange capabilities and cannot afford scanning channels. Therefore, it is essential for IEEE 802.11p radios to be, by default in the same channel and configured with the same Basic Service Set Identification (BSSID) to enable safety communication. A station in WAVE mode is allowed transmitting and receiving data frames with the wildcard BSSID value and without the need to belong to a BSS of any kind. This means, two vehicles can immediately communicate with each other upon encounter without any additional overhead as long as they operate in the same channel using the wildcard BSSID. So when the crashed car transmits the emergency messages, the other vehicle that near the car will get the message immediately. Upon receiving the message, the driver can make an action by stay in caution. Then send the message to other cars in the ad hoc network environment (Weidong Xiang, 2008).